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Diversity and Distribution of Ant Fauna in Hejamadi Kodi Sandspit, Udupi District, Karnataka, India

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Abstract

Ants are highly diverse and successful in varied habitats. The present study records diversity and distribution of ant fauna in Hejamadi Kodi sandspit (13° 04' to 13° 05' N latitude and 74° 46' E longitude) located in Udupi district, west coast of Karnataka during November and December, 2011. The spit is 1.2 km long with an area of 0.332 km^2. The river Shambavi flows along the east side of the spit parallel to the Arabian sea and joins the sea on the southern end of the spit. The temperature and humidity ranges from 22° to 33°C and 86 to 90 % respectively. The ant samples were collected using random transects following all out search, bait and pit-fall methods from each demarcated area categorized on the basis of nature of vegetation complex as zone (I) - sandy beach; (II-A) - thick creepy vegetation with scanty shrubs and (II-B) - thin creepy vegetation with moderate number of shrubs; (III) - mixed vegetation with wild and planted flora; (IV) - mangroves and (V) - coconut plantation. A total of 31 species belonging to 17 genera have been placed under five subfamilies (Formicinae, Myrmicinae, Ponerinae, Dolichoderinae and Pseudomyrmecinae). The data on distribution of ants records the highest number of species in zone IIIrd, followed by Vth, IIA, IIB, and IVth. The alpha diversity index values suggest that zone Vth is more diverse and have even distribution of ant species which probably may be attributed to the varied vegetation type; soil attributes in particular the temperature and the calcium carbonate level among the demarcated zones. However, the exclusive absence of ants specifically in the sandy beach zone may be attributed to constant tidal influx and the total absence of any kind of vegetation.

Keywords: *Ant fauna; Biodiversity indices; Coastal habitat; India; Sandspit; Karnataka.*

Introduction

The coastal area is one of an important zone of the terrestrial ecosystem. The coastal habitats are typically known to harbor rich biodiversity. Ants are considered useful for monitoring as they are abundant and ubiquitous in both intact and disturbed areas (Andersen, 1990; Pearson, 1994; Andersen, 1997; Folgarait, 1998; Hoffman *et al.*, 2000; Delabie *et al.*, 2006).

Earlier studies documenting the presence of ants in the coastal environment have recorded the effects of fire ants on sea turtle nesting beaches in Florida and on neonatal American alligator in the southeastern United States (Allen *et al.*, 2001a, b). A few ants, *Iridomyrmex pruinosus analis* and *Brachymyrmex depilaris* have been documented strictly intertidal

from the Gulf of California, Mexico (Yensen *et al.,* 1980; Maitland and Maitland, 1994). A study reporting diversity and habitat preferences of ant assemblages in Department of Atomic Energy (DAE) campus Kalpakkam situated on southeast coast of India suggests that scrub jungle and riparian woods are most diverse habitat followed by the monoculture and sandy area indicating that vegetation type, soil characteristic and anthropogenic disturbances influence the ant assemblage (Ramesh *et al.,* 2010).

The west coastal segment along Dakshina Kannada and Udupi district represents spits of different sizes and shapes. A spit or sandspit is a ridge or embankment of sediment attached to the land at one end and terminates into the open water at the other end (Evans, 1942). Ants play an important role in soil turnover and the nutrient recycling (Lal, 1988). There is no report documenting ant faunal diversity and distribution in the specialized habitats of the coastal spits. The present study, therefore aimed to record diversity and distribution of ant fauna in Hejamadi Kodi spit, Udupi district, Karnataka, India.

Material and Methods

The Hejamadi spit situated (between 13° 04' to 13° 05' N latitude and 74° 46' E longitude) in the southern part of Udupi district, west coast of Karnataka, India (Fig. 1) is 1.2 km in length with an area of 0.332 km^2. The river Shambavi flows along the east side of the spit parallel to the sea and joins Arabian sea on the southern end of the spit. The climate of the study area is warm, humid and receives an annual rainfall of about 160 inches. The temperature and humidity ranges from 22°-33°C and 86-90% respectively. The study area was demarcated into five zones based on the presence of predominant type of vegetation viz. (I) - sandy beach – no vegetation covering an area of about 5.261 ha; (IIA) - thick creepy vegetation with scanty shrubs covering an area of 5.6 ha and (II B) - thin creepy vegetation with moderate number of shrubs covering an area of 4.6 ha; (III) – mixed vegetation covering an area of 14.75 ha having wild and planted flora; (IV) – mangroves plants with an area of 0.479 ha and (V) – coconut plantation covering an area of about 2.5 ha (Fig. 1).

The samples were collected during November and December, 2011 using random transects of 10 x 10 m in each demarcated zone. Various methods employed for collection of the ant fauna includes all out search (hand collecting), pitfall and bait methods. Plastic cups (9 cm in diameter and 15cm in length) filled with ethylene glycol (5%) as the killing agent were kept in the center of transect. Dry coconut, sugar, honey and fried items were used as baits, placed at the four corner of the each transect. The collected ant samples were persevered in 70% alcohol and identified using appropriate keys (Bingham, 1903; Bolton, 1994). The floral species encountered are listed in Table 1. The abiotic parameters (pH, salinity, calcium carbonate, total organic matter moisture content, air and soil temperature) of the different zones were recorded (Trivedy and Goel, 1986). The coordinate readings were noted down using global positioning system (GPS). The alpha diversity indices were obtained using Shannon's index (H'), Simpson's index of diversity (1-D) and Shannon's equitability (J) index using Past software ver. 2.17b (Hammer *et al.,* 2001) whereas β – diversity indices were obtained using Jaccard's and Bray – Curtis similarity coefficient values using Estimate S version 8.20 (Colwell 2004).

Results

The study area was demarcated into five zones based on the presence of predominant type of vegetation as (I) sandy beach with no vegetation; (II A) thick creepy vegetation with scanty shrubs and (II B) thin creepy vegetation with moderate number of shrubs; (III) mixed vegetation having wild and planted flora; (IV) mangroves and (V) coconut plantation. The ants collected from Hejamadi Kodi spit area in present study records the presence of a total of 31 species placed under 17 genera and 5 subfamilies (Table 2). The number of ant species placed under subfamily Myrmicinae counts highest (17) followed by Formicinae (9), Ponerinae (3) and one each under Dolichoderinae and Pseudomyrmicinae. The number of subfamilies recorded in the study area represents the presence of four subfamilies in IIIrd and three subfamilies each in IInd, IVth and Vth zones (Fig. 2). The overall percent distribution of subfamilies records the highest representation of subfamily Myrmicinae (55%) followed by Formicinae (32%), Ponerinae (7%), Dolichoderinae and Pseudomyrmicinae (3% each) (Fig. 2). The zone wise record lists the highest number of ant species in IIIrd followed by Vth, IIA, IIB, IVth and the total absence of ants in the Ist zone (Table 2). The genus *Tetramorium* is represented maximally (5 species) followed by *Monomorium* (4 species), *Camponotus* and *Crematogaster* (3 species each) and *Tapinoma* and *Tetraponera* (only one species each) in the study area (Table 2).

The species wise distribution of ants in the demarcated zones indicates the presence of *Paratrechina longicornis* and *Crematogaster subnuda* in all the four vegetative zones. Whereas, *Plagiolepis jerdonii*, *Camponotus compressus*, *Nylanderia* sp.1 and *Monomorium orientale* species were seen only in three vegetative zones (II, III and V) and certain ant species *Anochetus* sp. 1, *Camponotus sericeus*, *Camponotus oblongus*, *Crematogaster* sp. 2, *Diacamma* sp. *Meranoplus bicolor* and *Tetramorium obesum* were recorded only in zone Vth. On the other hand *Anoplolepis gracilipes*, *Crematogaster* sp. 1, *Nylanderia* sp. 2, *Oecophylla smaragdina*, *Tetramorium* sp. 1 and *Tetramorium* sp. 2 were restricted only in zone IIIrd, whereas *Tetraponera nigra* was recorded only in zone IVth (Table 2). Further the association of ant species with plant taxa was also found to vary. Eleven ant species were confined to the specific plant taxa whereas ten species were encountered on more than one plant taxa (Figs. 3).

The number of ant nests recorded also varied in different zones (Table 2; Fig. 4). The total number of ground nests encountered was highest in zone IIA followed by IIIrd, IIB and the least in zone Vth. Whereas the *Crematogaster subnuda* and *Tetraponera nigra* had exclusively arboreal nests. The nests of *Tapinoma melanocephalum* were sighted both in sandy ground and on the twigs of *Wedelia trilobata.*

The environmental variables, number of floral and ant species records significant variations between the zones (Tables 1, 2 and 3; Fig 5). The Shannon's diversity, Simpson's index of diversity and Shannon equitability values (alpha diversity indices) were calculated (Table 4). The dendrogram generated using Jaccard's classic and Bray–Curtis similarity coefficient values based on the number of shared species (Fig. 6) records the highest similarity between Zone IIA and Zone IIB at the level of 0.688 and 0.815 respectively.

Table 1: List of floral species found in the demarcated zones.

Plant species	Zone I	Zone IIA	Zone II B	Zone III	Zone IV	Zone V
Ipomea pes - capre	-	+	+	+	-	+
Canavalia rosea	-	+	+	+	-	-
Spinifex littoreus	-	+	+	+	-	-
Cuscuta chinensis	-	+	+	+	-	-
Derris scandens	-	+	+	-	-	+
Sesuvium portulacastrum	-	+	-	+	+	-
Wedelia trilobata	-	+	+	+	-	+
Scaevola taccada	-	+	+	+	-	+
*Casuarina equisetifolia**	-	+	+	+	-	-
Morinda citrifolia	-	-	-	+	+	+
Cassia tora	-	-	-	+	-	+
Clerodendrum inerme	-	-	-	+	-	+
Pongamia pinnata	-	-	-	+	-	-
*Acacia auriculiformis**	-	-	-	+	-	-
Thespesia populnea	-	-	-	+	-	-
*Pterocarpus sp.**	-	-	-	+	-	-
Cerbera odollum	-	-	-	-	-	+
Mimosa pudica	-	-	-	-	-	+
Leucas aspera	-	-	-	-	-	+
Tridax procumbens	-	-	-	-	-	+
*Cocos nucifera**	-	-	-	-	-	+
Avicennia officinalis	-	-	-	-	+	-
Sonneratia alba	-	-	-	-	+	-

* Planted flora in the study area.

Table 2: Check list of ant species recorded in the demarcated zones of the study area.

Subfamily	Species	Zone I	Zone IIA	Zone IIB	Zone III	Zone IV	Zone V
Formicinae	1. *Anoplolepis gracilipes* Smith, 1857	-	-	-	+[a]	-	-
	2. *Camponotus compressus* (Fabricius, 1787)	-	+	+	+	-	+[a]
	3.*Camponotus oblongus* (Smith, 1858)	-	-	+	-	-	+
	4.*Camponotus sericeus* (Fabricius, 1798)	-	-	-	-	-	+
	5.*Oecophylla smaragdina* (Fabricius, 1775)	-	-	-	+	-	+
	6.*Paratrechina longicornis* (Latreille, 1802)	-	+[a]	+[a]	+[a]	+	+
	7.*Nylanderia* sp.1	-	+[a]	+	+[a]	-	+[a]
	8.*Nylanderia* sp.2	-	-	-	+	-	-
	9.*Plagiolepis jerdonii* Forel, 1894	-	+[a]	+[a]	+[a]	-	+[a]
Myrmicinae	10.*Cardiocondyla nuda* (Mayr, 1866)	-	+[a]	-	+	-	-
	11.*Crematogaster subnuda* Mayr, 1879	-	+[b]	+	+[b]	+[b]	+[b]
	12.*Crematogaster* sp.1	-	-	-	+	-	-
	13.*Crematogaster* sp.2	-	-	-	-	-	+[a]
	14.*Meranoplus bicolor* (Guérin-Méneville, 1844)	-	-	-	-	-	+[a]
	15.*Monomorium floricola* (Jerdon, 1851)	-	-	+	-	-	-
	16.*Monomorium orientale* Mayr, 1879	-	+[a]	+	+[a]	-	+
	17.*Monomorium pharaonis* (Linnaeus, 1857)	-	+	+[a]	+	-	-
	18.*Monomorium* sp.1	-	+[a]	+[a]	+[a]	-	-
	19.*Pheidole* sp.1	-	+[a]	+[a]	+[a]	-	-
	20.*Solenopsis geminata* (Fabricius, 1804)	-	+[a]	+[a]	-	-	-
	21.*Solenopsis nitens* Bingham,1903	-	+	-	-	-	-
	22.*Tetramorium obesum* André, 1887	-	-	-	-	-	+[a]
	23.*Tetramorium smithi* Mayr, 1879	-	+	-	+[a]	-	+[a]
	24.*Tetramorium walshi* (Forel, 1890)	-	-	+[a]	+[a]	-	+
	25.*Tetramorium* sp. 1	-	-	-	+[a]	-	-
	26.*Tetramorium* sp. 2	-	-	-	+	-	-
Ponerinae	27.*Anochetus* sp.1	-	-	-	-	-	+
	28.*Anochetus* sp.2	-	-	-	-	-	-
	29.*Diacamma* sp.	-	-	-	-	-	+[a]
Dolichoderinae	30.*Tapinoma melanocephalum* (Fabricius, 1793)	-	+[a]	+[a]	+[b]	-	-
Pseudomyrmecinae	31.*Tetraponera nigra* (Jerdon, 1851)	-	-	-	-	+[b]	-
Total number of species		**0**	**14**	**13**	**20**	**3**	**15**
Number of arboreal nesting species		**0**	**1**	**0**	**2**	**2**	**1**
Number of ground nesting species		**0**	**9**	**8**	**10**	**0**	**8**

[a] Ground nest (Subterranian nest with or without prominent mound, beneath the wood, pebbles).
[b] Arboreal nest (constructed in or outside the stems or using leaves)

Table 3: The record of abiotic parameters (pH, salinity, $CaCO_3$, total organic matter, moisture content and air and soil temperature) and the correlation coefficient values between abiotic parameters and the number of plant and ant species in respective zones.

No. of ant species	No. of plant species	Soil Temperature (° C)	Air Temperature (°C)	pH	$CaCO_3$ (%)	Moisture Content (%)	Total organic Matter (%)	Salinity (ppt)	Zones
0	0	21.8 ± 1.04	27.25 ± 1.2	6.70 ± 0.3	4.25 ± 0.87	5.03 ± 0.9	0.63 ± 0.3	0.27 ± 0.12	Zone I
14	9	35.69 ± 6.2	32.65± 2.6	6.76 ± 0.21	5.61 ± 0.94	1.13 ± 0.3	2.1 ± 0.48	0.03 ± 0.01	Zone IIA
13	8	39.35±7.1	34.44± 2.4	6.70 ± 0.22	5.82 ± 1.21	0.04 ± 0.1	2.06 ± 0.29	0.06 ± 0.13	Zone IIB
20	15	39.55± 7.5	33.76±2.3	6.76 ± 0.19	4.72 ± 0.86	0.6 ± 0.2	2.19 ± 0.33	0.03 ± 0.02	Zone III
3	4	21.1± 0.35	34.4± 1.4	6.77 ± 0.09	2.1 ± 0.14	5.2 ± 0.6	2.28 ± 0.3	0.45 ± 0.21	Zone IV
15	12	31.63± 4.9	32.25± 3.4	6.75 ± 0.21	6.1 ± 1.7	1.33 ± 0.4	1.69 ±0.55	0.04 ± 0.03	Zone V
-	-	<0.0001	<0.0001	>0.05	<0.0001	<0.0001	<0.0001	<0.0001	P - value
Correlation coefficient values between abiotic parameters and the number of plant and ant species in respective zones									
-0.86	-0.75	-0.89	0.14	0.07	-0.92	0.94	-0.17	1	Salinity (ppt)
0.57	0.6	0.5	0.81	0.65	-0.07	-0.47	1		Total organic Matter (%)
-0.94	-0.85	-0.98	-0.21	-0.05	-0.81	1			Moisture Content (%)
0.64	0.52	0.72	-0.31	-0.31	1				CaCO3 (%)
0.33	0.47	0.01	0.23	1					pH
0.24	0.25	0.31	1						Air Temperature (°C)
0.91	0.8	1							Soil temperature (°C)
0.97	1								No. of plant species
1									No. of ant species

All abiotic parameter Values are mean ± SD

Discussion

Ants are terrestrial invertebrates frequently found in coastal or intertidal environment (Allen *et al.*, 2001a). The spit, a heterogeneous ecosystem demarcated into five zones in present study suggest significant variations between the zones based on vegetation complex and soil characteristics (Table 1; Figs. 5 and 7). A total of 31 species placed under 17 genera and 5 subfamilies recorded in present study (Table 2) suggest the presence of a rich and diverse ant fauna in Hejamadi Kodi spit, the coastal landform. The Myrmecinae ants dominated in all the zones (Fig. 2) and the zone wise distribution suggest the highest number of ant species in IIIrd zone (mixed vegetation) followed by the Vth (coconut plantation), IIA (creepy vegetation), IIB (creepy vegetation with moderate shrubs) and IVth zone (mangrove). The total absence of ant fauna in Ist zone may be attributed to the constant tidal influx and the total absence of any kind of vegetation. The selective distribution of *Paratrechina longicornis* and *Crematogaster subnuda* in zones IInd, IIIrd, IVth and Vth ; whereas *Anochetus* sp. 1, *Camponotus sericeus*, *Camponotus oblongus*, *Crematogaster* sp. 2, *Diacamma* sp. *Meranoplus bicolor* and *Tetramorium obesum* only in zone Vth; *Anoplolepis gracilipes*, *Crematogaster* sp. 1, *Nylanderia* sp. 2, *Oecophylla smaragdina*, *Tetramorium* sp. 1 and *Tetramorium* sp. 2 only in zone IIIrd; and *Tetraponera nigra* only in zone IVth suggest association/dependence of ant species on specific host plants and the associated fauna for food and shelter. Earlier reports too have also documented that vegetation kind/pattern influences the richness and distribution of ant species (Kusnezov, 1957; Boomsma and Van Loon, 1982b; Gadagkar *et al.*, 1993; Bonte *et al.*, 2003; Palomo *et al.*, 2003; Cardoso *et al.*, 2010).

In addition the percent level of $CaCO_3$, total organic matter, moisture content, temperature of air and soil, pH and salinity (Table 3) recorded in the present study points that in particular $CaCO_3$ and temperature of the soil play a significant role probably contributing to the varied distribution of ant species, thereby conferring ability to survive in otherwise harsh environment (Boomsma and Isaaks, 1982a) which suggest varied toleration range for different ant species to environmental variables (Holldobler and Wilson, 1990) permitting temporal resources partitioning (Orivel and Dejean, 2001). The pattern of distribution of ground nest probably relates to the availability of food resources and vegetation complexity (Table 1 and 2; Fig. 8) which in turn probably plays an important role in soil turnover and the nutrient recycling (Lal, 1988). Some species of ants occupied the nest constructed by other organisms (Fig. 4). Whereas the *Crematogaster subnuda* (zone IIA, IIIrd, IVth and V) and *Tetraponera nigra* (zone IVth with mangrove) had exclusively arboreal nests suggesting that the tidal influx probably limits the activity of ants to the crown of the trees (Lopes and Aguiar dos Santos, 1996; De Baar and Hockey, 1993). The nests of *Tapinoma melanocephalum* were sighted both in sandy ground as well as on twigs of *Wedelia trilobata* suggesting that *Tapinoma melanocephalum* is comparatively highly adapted to environmental variables (Andersen, 1990).

Shannon index and Simpson's diveristy index, the measures of alpha diversity suggest that the zone Vth is more diverse followed by III, IIB and IIA (Table 4). The computed evenness values (Shannon

equitability) suggest that the distribution of ant species is more even in zone Vth followed by IIB, III and IIA. The dendrogram obtained using Jaccard's classic and Bray–Curtis similarity coefficient values (beta diversity indices) indicates highest similarity between Zone IIA and Zone IIB at the level of 0.688 and 0.815 respectively (Fig. 6). More or less similar species richness shared between zone IIA, IIB and IIIrd probably relates to more or less the similar vegetation type in these zones (Table 1).

The diversity and distribution pattern of ant species observed in demarcated zones in present study points to the selective needs (in terms of food and shelter) and adaptive capabilities of ant species to harsh prevailing conditions (Andersen, 1990) compared to inlands particularly with reference to the soil temperature, $CaCO_3$ and the type of plant species found in specialized habitats of the sand spit permitting selective association between flora and fauna and thus contributing to their successful survival and reproductive fitness in the harsh conditions met in on coastal habitats.

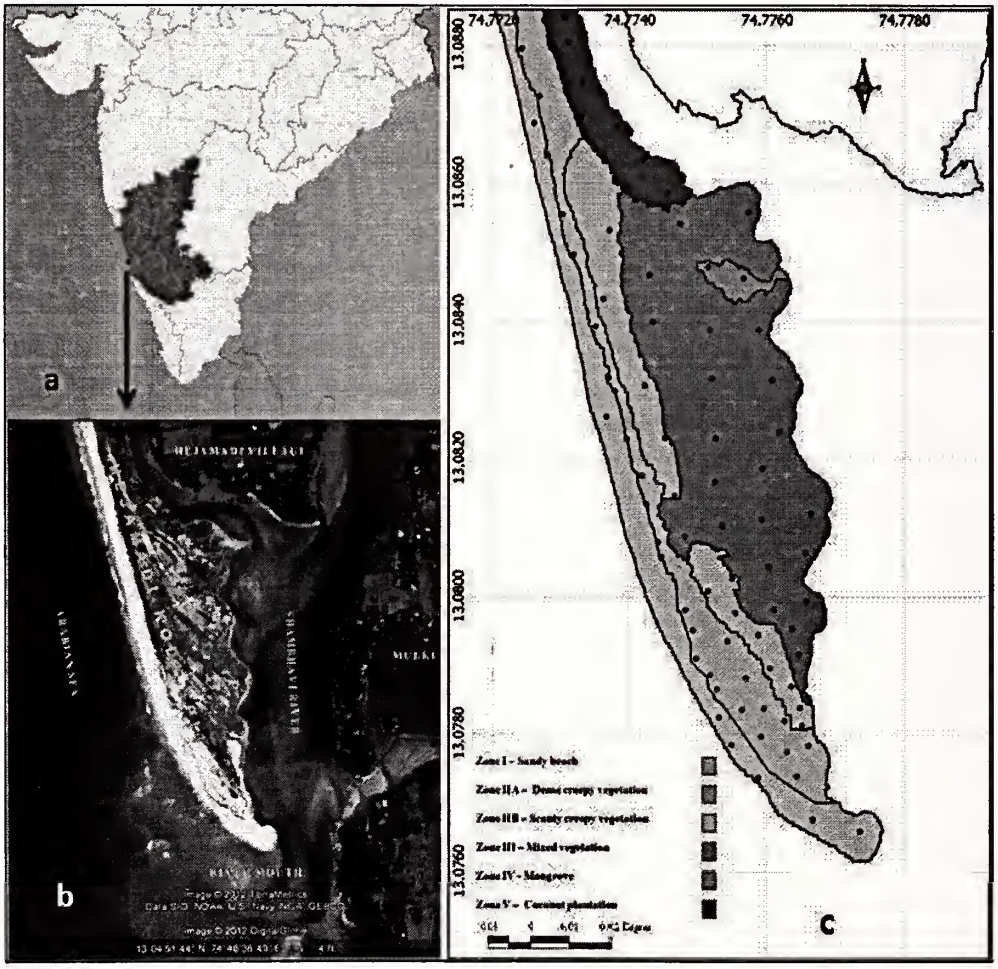


Fig. 1: A map showing a) location of Udupi district b) Google image of Hejamdi Kodi spit and c) demarcated zones and sampling points (•).

Table 4: Diversity indices for demarcated zones in the study area.

Zones	No.of species	Shannon[a] (H')	Simpson index[b] (1-D)	Shannon equitability [c](J)
Zone IIA	14	2.098	0.8471	0.7949
Zone IIB	13	2.189	0.8613	0.8536
Zone III	20	2.402	0.8689	0.8018
Zone IV	3	**	**	**
Zone V	15	2.588	0.918	0.9556

[a] The values ranges between 1.5-3.5 and values nearing 1.5 is considered to be less diverse.
[b] The values ranges between 0-1 and values nearing 0 is considered to be less diverse.
[c] The values ranges between 0-1 and values nearing 0 is considered to be more uneven.
** Not computed due to small sample size.

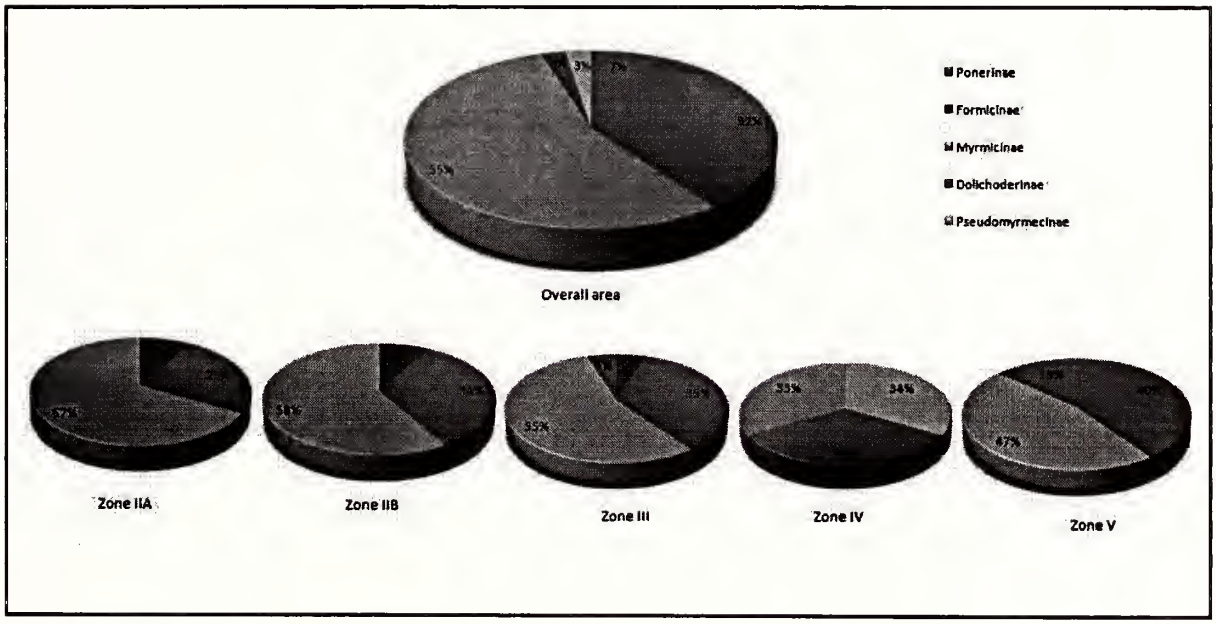
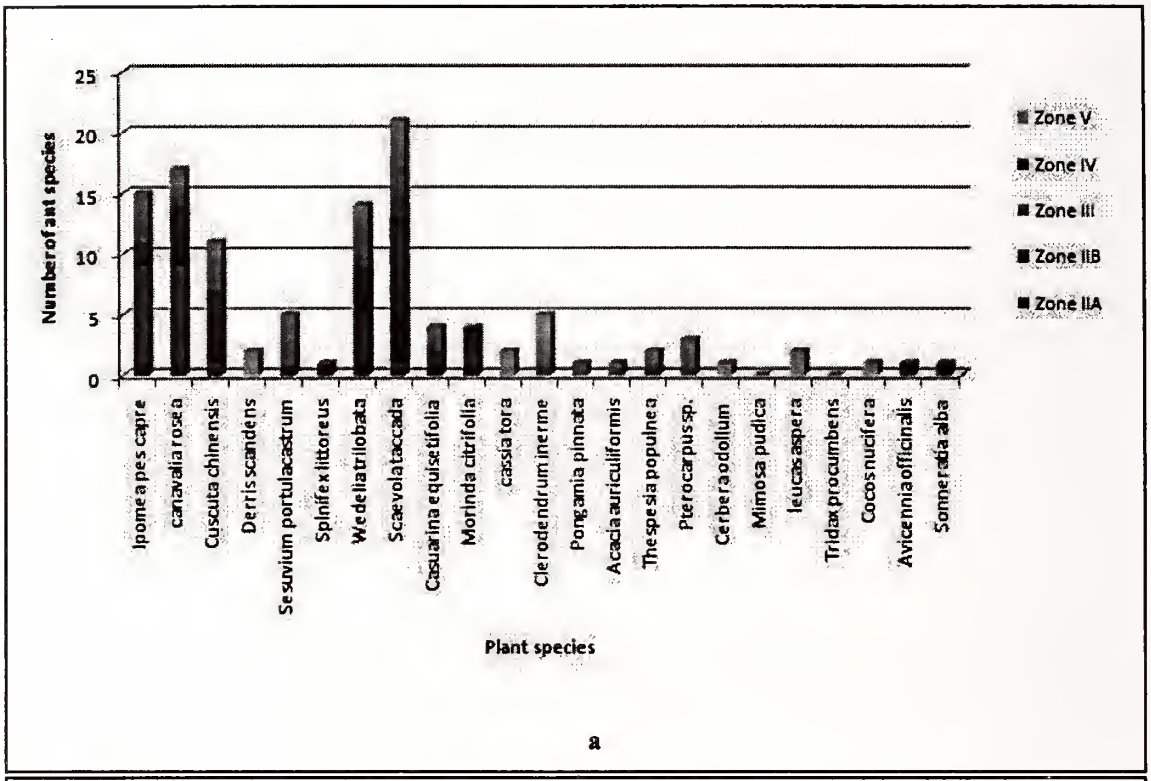
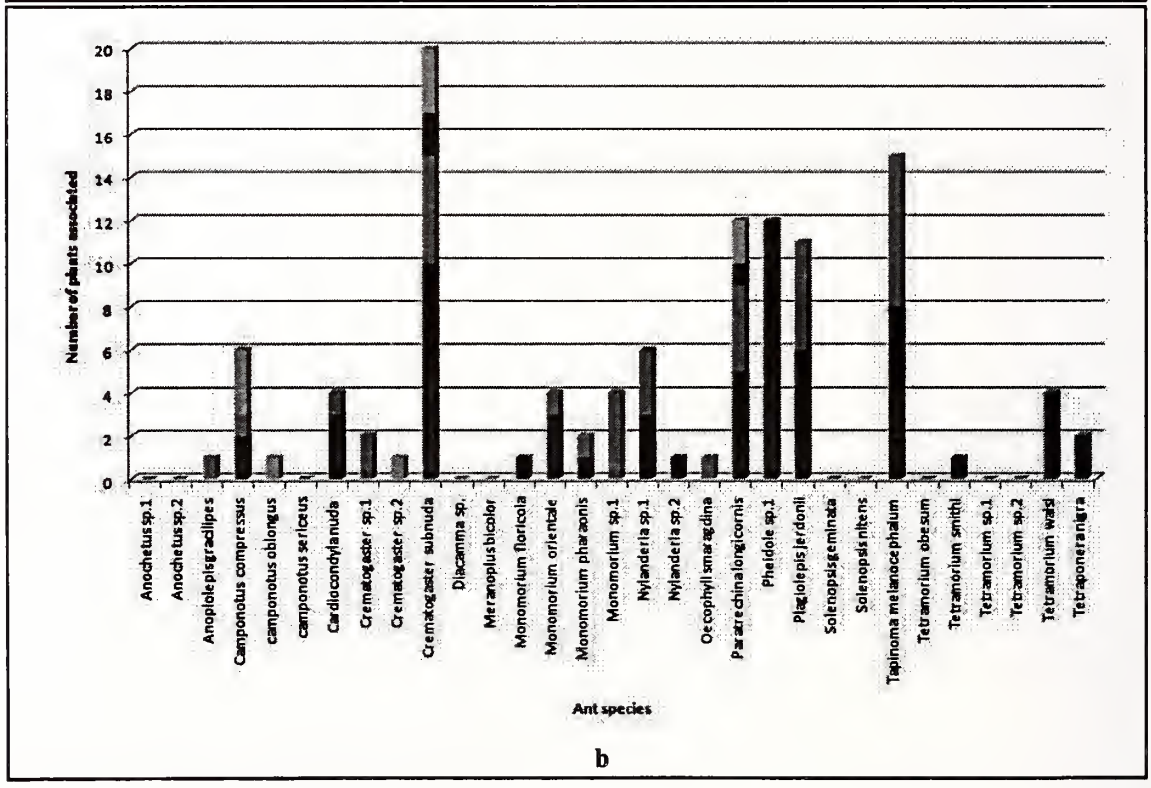


Fig. 2: Percent occurrence of subfamilies in the study area.



a



b

Fig. 3: The association between a) number of ant species with plants b) ant species with number of plants in the demarcated zones.

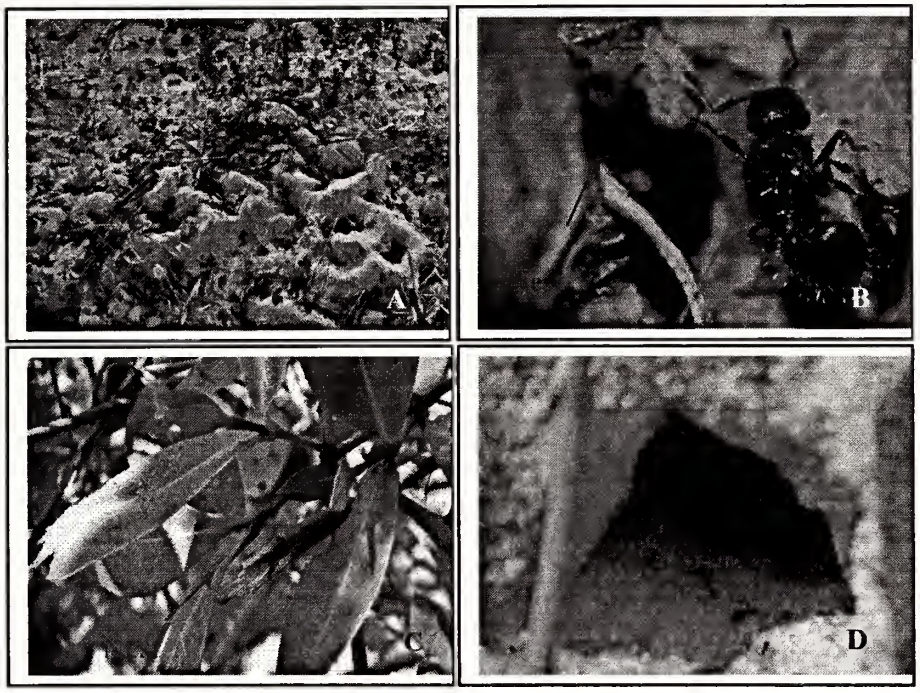


Fig. 4: Nest of (A) *Pheidole* sp., (B) *Crematogaster* sp., (C) *Tetraponera nigra* and (D) *Paratrechina longicornis* using the holes made by crabs.

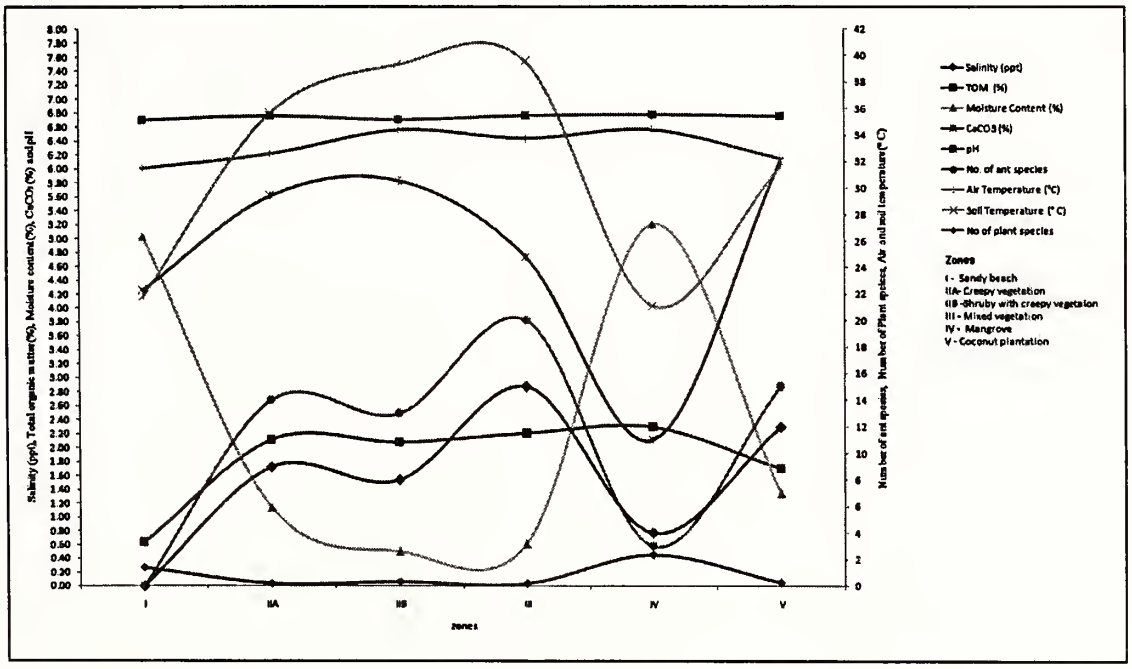


Fig. 5: The correlation between abiotic parameters (pH, salinity, $CaCO_3$, total organic matter, moisture content and air and soil temperature) and number of plant and ant species in respective zones.

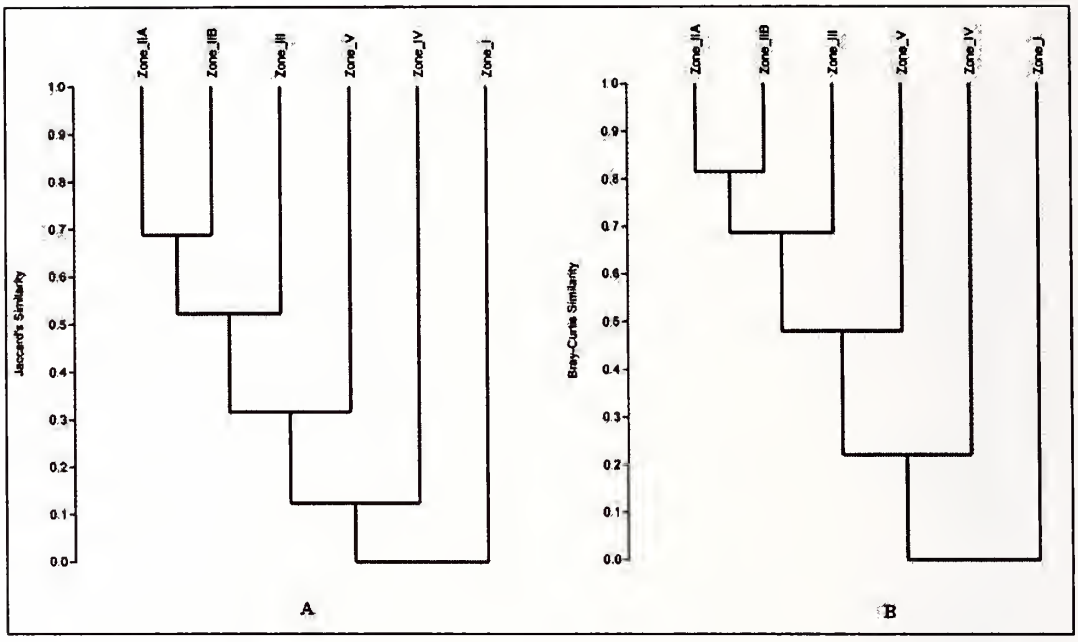


Fig. 6: Dendrogram generated using (A) Jaccard's similarity and (B) Bray-Curtis similarity coefficient values based on the number of shared species between the habitats.

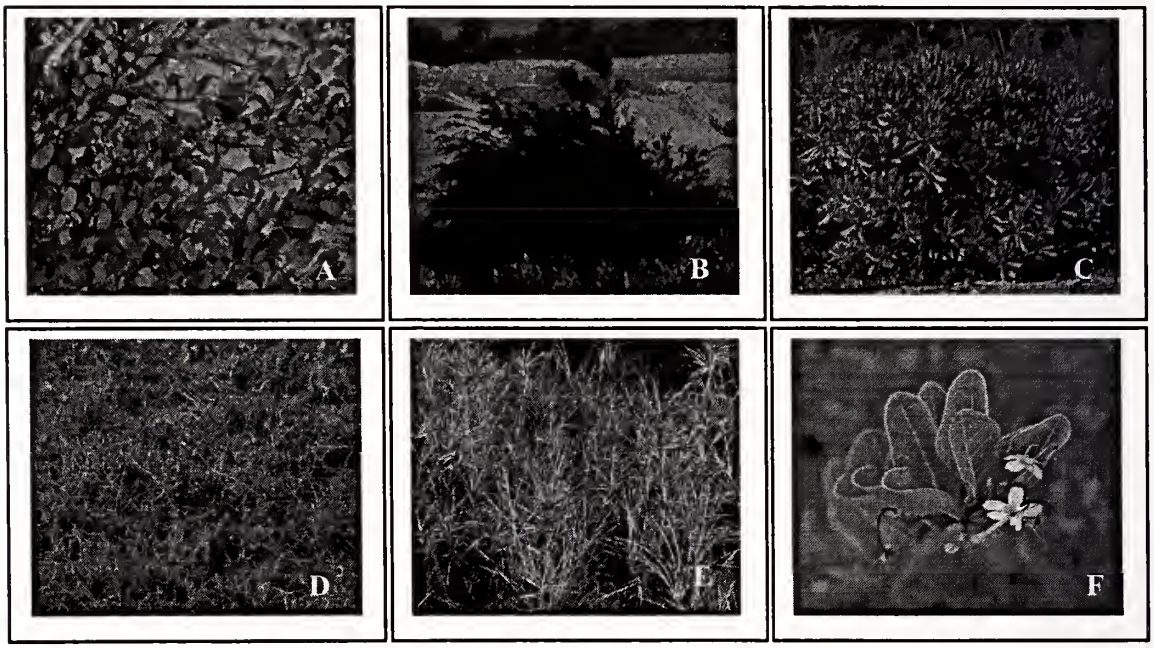


Fig. 7: Figures of some common plant species in the study area. A. *Ipomea pes - capre*, B. *Casuarina equisetifolia*, C. *Scaevola taccada*, D.*Cuscuta chinensis*, E. *Spinifex littoreus*, D. *Clerodendrum inerme*.

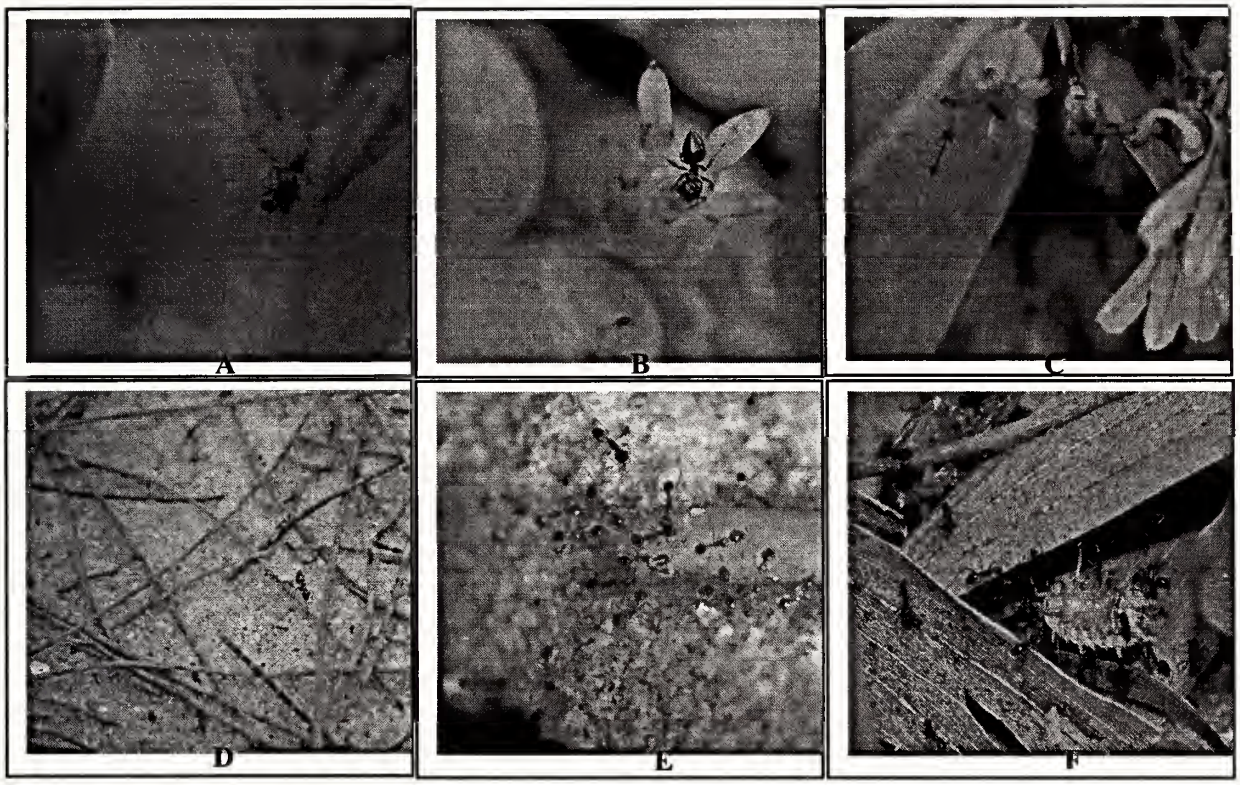


Fig. 8: Foraging ants in search of food – (A) The *Pheidole* sp. seen at the base of *Ipomea pes - capre* for extrafloral nectaries; (B) *Crematogaster* sp. and (C) *Paratrechina longicornis* reaching the fruit of *Scaevola taccada* for extrafloral nectaries; (D) *Pheidole* sp. carrying a crustacean and (E) the bait (fried item) material; (F) *Paratrechina longicornis* carrying a crustacean.

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